A GEOSPATIAL ANALYSIS OF WETLAND: LAKE KABARTAL, BEGUSARAI (BIHAR)

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Introduction

Wetlands are places in between chronically flooded deepwater environments and well-drained uplands; in the former, the ground is often covered with shallow water, or the water table is at or near the surface (Cowardin et al., 1979, usgs.gov). According to Ramsar Convention, “wetlands are areas of marsh, fen, peat land or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters" (Ramsar Convention, 1971). The main wetland types are swamp, marsh, bog, and fen, and subtypes include mangrove forests, carr, floodplains, sink, and many others (Mitsch W J and Gosselink J G, 2015). Wetlands have great ecological and economic significance, and the conservation of wetlands has gained momentum in recent years due to their significant role in ecological and hydrological processes (Ranjan et.al 2016). Wetlands provide habitat for thousands of species of aquatic and terrestrial plants and animals which play a vital role in the ecosystem and the food chain (Mitsch and Gosselink, 2007). Among the most productive environments on the planet, wetlands serve as wintering grounds for migratory birds as well as refuge and nidification sites for creatures like fish and shellfish that are essential to both commercial and recreational interests (Kumar, Rahul et.al 2021, nps.gov). The earth's most biologically diverse and productive ecosystems are found in natural floodplain wetlands, yet they are also some of the most vulnerable (Mitsch and Gosselink, 2000). A transformation of the native land cover to agricultural land has been recognized as one of the key reasons for the wetland loss globally (Bayley et al., 2013). It is believed that the world has lost 50% of its wetlands in the twentieth century to agriculture and urbanization (Rijsberman and de Silva, 2006). Many threats also faced by wetlands are urbanization, agricultural activities, climate change, pollution, dredging, draining, introduced species, and salinization. The extent of the world’s wetlands is from 7 to 10 million km², or about 5 to 8 per cent of Earth's land surface (Mitsch and Gosselink 2015). Wetlands are distributed in every part of the world except Antarctica (Tiner 2009). Approximately, half of the global wetland area occurs between 50°N and 70°N latitude, one-third between 20°N and 30°S latitude, and the remaining in the temperate zones (Tiner 2009). Western Siberian Lowland is considered the world's largest wetland in the region of central Russia. Some of the other major wetlands of the world are the Amazon River Basin in South America, the Hudson Bay Lowland in North America, the Congo River Basin in Africa, and

the Mackenzie River Basin in North America. According to the National Wetland Portal, 7,57,040 wetlands cover 1,52,60,572 hectares (15.26 million hectares) in India, which is about 4.63% of the country's total geographical area. The area under inland wetlands is 10.56 million hectares and the area under coastal wetlands is 4.14 million hectares (NWIA 2011). India became a party to the 'Convention on Wetlands', also known as the Ramsar Convention on 1st February 1982. Since then, 80 wetlands have covered an area of 13,41,884 hectares under the List of Wetlands of International Importance (Ramsar.org). The total wetland area estimated in Bihar is 403209 hectares, which is around 4.4 per cent of the geographic area (NWIA 2011). The major wetland types are river/stream accounting for about 74 per cent of the wetlands (298408 hectares), natural waterlogged (34878 hectares) lake/pond (20281 hectares), and ox-bow lake/ cut-off meander (16172 hectares) (NWIA 2011). The major rivers which contribute to different wetlands in Bihar are Ganga, Kosi, Gandak, Bagmati, Mahananda, and Kamla-Balan (Ghosh et al. 2004). The major wetlands of Bihar are Kabartal, Baraila, and Kushehwarsthan. Kabartal Lake is the only Ramasar site in Bihar covering 2620 hectares (Ramasar Info Sheet). There are seven Wetlands of International Significance including Mokama Taal Wetland in Purbi Champaran, Nakti Dam Bird Sanctuary in Katihar, Chaurs of North Bihar in Patna, Diyara Flood Plain in Pashchim Champaran, Gogabil Pakshi Vihar Baghar Beel and Baldia Chaur in Patna, Kursela River Course in Purba Champaran, and Kusheshwarsthan in Darbhanga (National Wetland Atlas 2011). The total area covered by wetlands in Begusarai is 20365 hectares (National Wetland Atlas 2011). The major wetlands of Begusarai are Basahi Wetland (Nagri Jheel), Ekamba, and Kabartal. Kabartal Wetland is the only Ramasar site in Bihar, an Oxbow Lake. Kabartal is one of the largest natural oxbow lakes in India. This wetland lies in the middle Gangetic plain, with an alluvial landscape. It formed due to the meandering of river Budhi Gandak in the geological past which is a tributary of the river Ganga (Kumari et.al.2023). Situated in the depression between the paleochannel of the River Bagmati and the Burhi Gandak River, Kabartal is the largest of a group of shallow, permanently flooded wetlands that are also periodically inundated (Ramasar Information Sheet).

Review of Literature

Singh, Manudeo et.al. (2021) analyzed wetland health using hydrogeomorphic indicators such as wetness dynamics with the help of MNDWI, vegetation dynamics by NDVI, shoreline change, and patch dynamics with the help of multi-temporal remote sensing data. Linear trends of MNDWI and NDVI have been calculated for the post-monsoon, spring, and pre-monsoon seasons for the period of 1988–2016. Theil-Sen estimator, a simple linear regression method has been applied. The decadal-scale shoreline change (shrinkage/advancement) assessment has been done using the Digital Shoreline Analysis System (DSAS, v4.0) software of USGS. This study shows that the vegetation cover and density have been increasing, and the wet areas have been decreasing in the Kaabar Tal for the last 30 years. The open water areas of this wetland have been transformed into a vegetated marsh in less than a decade. Rainfall is the prime factor for the hydrodynamics of the Kaabar Tal according to this study.

Ranjan, Rakesh Kumar et.al. (2018) studied the impact of land use and land cover changes on nutrient concentration in and around Kabar Tal Wetland. Landsat satellite images from 1990, 2010, and 2015 have been taken for this study with a resolution of 30 meters. Arc GIS 10.2.2. and Erdas Imagine 2014 have been used for the classification of images. Unsupervised classification has been employed and accuracy assessment has been done with the help of kappa coefficients. Nutrient concentration data has been taken from published sources. A/c to this study, the open water area is continuously decreasing from 12% in 1990 to 4.8% in 2015. Agricultural area and fallow land are gradually increasing from 48.18% in 1990 to 59.13% in 2015 and from 39.8% in 1990 to 36.07% in 2015 respectively. This study also tells us about the eutrophic nature of the Kabar Tal due to the increasing concentration of major nutrients (phosphorus and nitrogen). Also, there is a strong correlation between changes in land use and nutrient concentration in the lake.

Harshita, Hansda et.al. (2017), assessed water quality of Kanwar Lake. Water samples have been collected at an interval of six months from ten different spots. Water has been slightly acidic to alkaline throughout the period. The electrical conductivity of Kanwar lake water ranges between 0.11 to 0.36mS/cm. The turbidity of Kanwar Lake water ranges between 0.1 to 5.1 NTU. The total dissolved solids of Kanwar lake water ranges between 108 to 570 mg/l. The total alkalinity of Kanwar lake water ranges between 5.0 to 20 mg/l. The chloride of Kanwar Lake water ranges between 4.2 to 10.4 mg/l. The total hardness of Kanwar lake water ranges between 81 to 125 mg/l. The calcium hardness of Kanwar lake water ranges between 41.8 to

69.1mg/l. Dissolved Oxygen in Kanwar lake water ranges between 2.2 to 5.6 mg/l. Biochemical Oxygen Demand of Kanwar Lake ranges between 1 to 5.2 mg/l. Chemical Oxygen Demand of Kanwar lake water ranges between 1.10 to 7.40 mg/l. Iron of Kanwar lake water ranges between 0.12 to 0.23 mg/l. This study concludes that pH, EC, Turbidity, Alkalinity, DO, COD, Fe, Chloride, Total Hardness and Calcium Hardness have been found under the permissible limits given by BIS. The BOD and TDS have been above the permissible limit.

Prakash, Bijay et.al. (2018) studied the strategies for the conservation of Kanwar Lake. Here, a primary survey has been done to understand the existing wetland function, services, and socio-economic status of the local community dependent upon the wetland for their livelihood purposes by selecting 10 revenue villages and taking 2.5% of the total population for the primary survey. Map has been created using Arc GIS and ERDAS. This study tells that approximately 8000 people are dependent upon the wetland for their daily cash income. There is no legal boundary, that's why conflict arises between different communities mainly between sahnis and farmers. The area of wetland is continuously shrinking and a comparison of the years 1986 and 2010 shows that it has reduced by 66 percent since 2004 and only 30 percent of the original coverage area is left, as recorded in 1984. Community co-management may help in the process of conservation and wise use of wetlands.

Ambastha, Kalpana et.al (2007) carried out research to find the economic linkages between the Kabartal wetland and the local people living around it using a socioeconomic survey and Contingent Valuation Method. 83.6% of the people around the wetland are willing to protect the wetland and its resources such as flora and fauna. There is a high dependency on the resources of the wetland for livelihood. The study says that there should be better policies that will be beneficial for wetlands as well as the people dependent on them.

Singh, Ajit et.al. (2020) estimated the water quality index on seventeen water parameters in the upper, middle, and lower stretches of the wetland between 2014 to 2016. According to this study, the water quality index value ranged from 73 to 79, which is of type II class and needs preliminary treatment before human consumption. Its quality is deteriorating across the stretches mainly due to inadequate water recharge, excessive siltation, and an increasing load of organic matter as well as heavy metals, which will lead to compromising the health of aquatic life as well as the life of the dependent population.

Singh, Ajit Kumar et.al. (2016) assessed the water quality by collecting water samples at three locations, outlet, inlet, and mid-lake by taking samples every month for one year. This study

finds that all the parameters are within permissible limits except DO. All the findings have been compared with previously published papers and it shows that the level of pollutants has increased in the lake, which must be checked to maintain the water quality and overall health of the wetland. It is also concluded from this study that mid-lake waters are not too much affected by different pollution sources, in comparison to the inlet and outlet waters.

Gupta, Deepak et.al. (2021) studied the impact of spatial and seasonal variability on the water chemistry of the Kabar Tal wetland using multivariate statistical techniques and GIS and checking the suitability of surface water for irrigation purposes. Principal component analysis, discriminant analysis, and correlation matrix for water samples have been carried out using 'Statistical Package for Social Sciences (SPSS). The contour map has been prepared through interpolation, by the Inverse Distance Weighted method. This study finds that the SAR (Sodium adsorption ratio) value of the study area is less than 10, which means surface water is favourable, and suitable for irrigation purposes. The major source of ions in water is weathering processes which is revealed with the Gibbs plot. The concentration of major cations such as sodium, potassium, calcium, and magnesium is higher in winter than in monsoon and summer. In addition, major anions like sulphate and phosphate concentration are higher during monsoon than in summer and winter. Overall study shows that seasonal variability plays an important role in the hydrochemistry and nutrient dynamics of the wetland.

Rai, S.C. et.al (2018) analyzed resource use, major problems and ways to conserve the Kabartal wetland ecosystem situated in the Begusarai district of Bihar. The Kabartal wetland is fed by rainwater or by overflowing of the rivers Budhi-Gandak and Bagmati during the rainy season. At present, water comes from its catchment area. A silt of about 3 cm has been deposited due to the inflow of silt through the runoff from the surrounding area. The water quality index is around 58 which indicates that the water quality is gradually deteriorating due to the discharge of domestic waste, consumptive and non-consumptive use of the lake, and excessive use of chemical fertilizers and pesticides in the agriculture field. According to this study, there has been a regular conflict between the fishermen's community and rich farmers as rich farmers widen the outflow channel so that the area becomes free from water for agricultural practices and the fishermen's community requires water for aquatic farming. Another conflict is between local people and the government for ownership of land.

F, Makarati et.al. (2021) studied the influence of rainfall variability on wetland size over time in Masvingo province, Southeastern Zimbabwe. Standardised Precipitation Index (SPI) has

been used to determine wet, dry and drought conditions using rainfall data. Topographical and orthophoto maps have been used to study the changes in wetland size. The study reveals that there is no direct linkage between rainfall variability and wetland sizes using the SPI index. This result has been further verified using ANOVA, Pearson's Correlation and T-test and finds no relation between the variables. This shows that there have been other physical and anthropogenic factors which led to wetland shrinkage.

Kuchara, Vishwa et.al. (2023) has studied wetland degradation due to the expansion of anthropogenic activities. There are a lot of issues related to wetland conservation such as poor management systems, no specific laws, the negative impact of water conservation projects and a lack of awareness among people. Here, a case study of various wetlands has been done to find out the possible reasons for its degradation. Keoladeo National Park, Chatra Wetland, Varthur Wetland, East Kolkata Wetland, Chhaya Rann Wetland and Gosabara Wetland have been continuously degrading due to uncontrolled growth rate of grass, urbanisation, sewage and industrial waste, increased rate of evaporation due to climate change and various other factors. This study focuses on the importance of wetlands how they impact both humans and nature and ways to conserve them.

Research Gap

Numerous studies on wetlands have been carried out. Lake Kabartal, which happens to be one of the Ramsar Sites has been studied by numerous scholars. Studies on parameters like land use land classification, chemical, biological, conservative manures, socio-economic parameters, etc. have been carried out. All studies have been in isolation and no holistic study has been done to date. Also, the periphery of the Wetlands and its source of water which has been fluctuating and changing from time to time has not been studied in detail. The water level and quality of water in the surrounding area of the wetlands have also not been studied.

The socio-economic parameters concerned only the impact and association of the wetlands with the livelihood of the people, but no specific study has been done regarding the livelihood and environmental aspects of the study area in the absence of the wetland. No specific studies have been done on the prevalence of disease in the surrounding area. Also, Lake Kabartal has been studied in isolation omitting the other wetlands in the study area. This study will emphasize a systematic and objective study of the wetlands of the study area regarding Lake Kabartal and try to evaluate the influence of rainfall, flood water, agricultural practices, over-exploitation of the wetland's hinterland, the role of migratory birds, and other flora and fauna

which influence the ecosystem of the wetland under study. The study will mainly concentrate on the geographical and geological parameters of the wetlands having humans as the focal theme.

Objectives

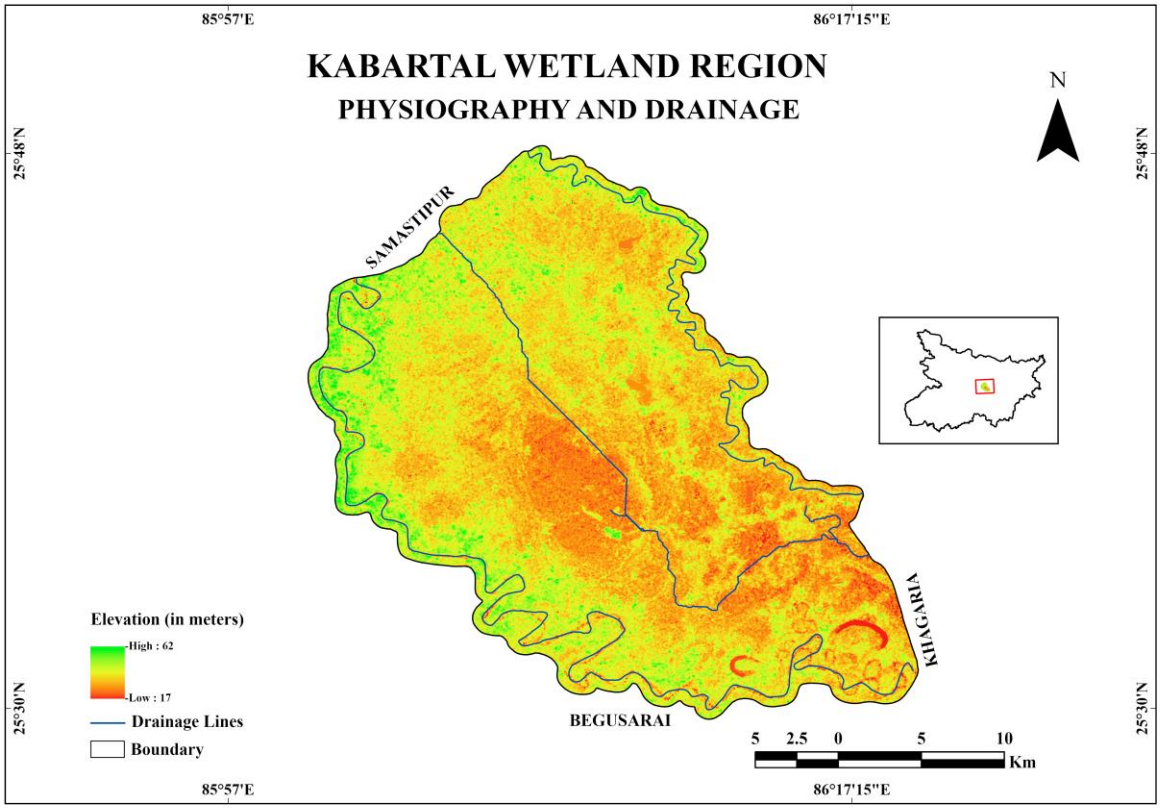
1. To present the classification of wetlands of the study area.
2. To assess the impact of rainfall variability on the wetlands.
3. To analyse the biogeochemical parameters of Kabartal Wetland.
4. To study the role of wetlands in shaping the natural and anthropological landscape and vice versa.
5. To analyse the role and impact of stakeholders on the environment of Kabartal Wetland.

Study Area

The natural study region has been carved along the two rivers and is located in the Gangetic plains, which are home to numerous wetlands of various sizes and layouts. The Kosi-Gandak interfan zone of the East Ganga Plains (EGP) is extensively filled by wetlands. This region is fluvially highly dynamic. The Burhi Gandak and Baghmati are the major rivers flowing through this interfluve along with many seasonal and minor streams. Owing to the flat terrain and aggradational regime, most of the rivers of this region exhibit decadal scale avulsions and have been termed as 'hyperavulsive'. The Burhi Gandak joins the Ganga River and the Baghmati drains into the Kosi River. The BudhiGandak River in the west and the Bagmati River in the east form the boundaries of this region. This region is primarily located in the Begusarai district, and Samastipur and Khagaria districts. There are various wetlands in this study area among which Lake Kabartal is one of the important wetlands.

Kabartal Lake is one of the largest natural oxbow lakes in India. This wetland lies in the middle Gangetic plain, with an alluvial landscape. It formed due to the meandering of river Budhi Gandak in the geological past which is a tributary of the river Ganga (Kumari et.al.2023). Situated in the depression between the paleochannel of the River Bagmati and the Budhi Gandak River, Kabartal is the largest of a group of shallow, permanently flooded wetlands that are also periodically inundated (Ramasar Information Sheet). Its area extent is 2620 hectares of the Indo-Gangetic Plain and is situated at 25°37'05"N latitude and 86°08'22"E longitude (Ramsar Information Sheet,2020). The Burhi Gandak, old Baghmati, and Chanha river drain

the area and during the monsoon season, it covers an area of 7,400 hectares because it get connected to nearby water bodies and receive water from nearby agricultural areas (Ambastha et al., 2007b). The average elevation of this region is 44 m above mean sea level (Singh et.al. 2021). Near the wetland, two significant streams flow. The first is a plains-fed channel to the west known as the Burhi Gandak (Sinha and Friend, 1994); the second is a minor seasonal stream to the east of the wetland known as the Chanha River. In the 1950s, the Burhi Gandak River was embanked on both sides to control floods (Singh et.al 2021). During pre-embankment times, the Burhi Gandak used to feed the Kanwar Tal during monsoon season (Singh et.al. 2016). At present, there is no recognized inflow stream in the wetland, and water from the catchment reaches via sheet flow and subsurface flow (Singh et.al.2021). An outflow canal was constructed to drain the wetland, which connects the wetland with the Chanha River which drains into the Burhi Gandak River (Singh et.al.2021). This region falls in the tropical monsoonal climatic zone and monsoon is the predominant season, which has a significant impact on both wetland dynamics and land usage (Singh et.al.2021). It mainly experiences four distinct seasons, winter (December– February), summer (March-May), monsoon (June–August), and post-monsoon (September–November) (Singh et.al.2021). The range of temperature is between 5°C to 45°C (Kumar, Rahul et.al 2021). The long-term average rainfall in the study area is 1200 mm, out of which 1016 mm is monsoonal contribution (Kothawale and Rajeevan, 2017). The soil in the study area is sandy, loam, and rich in humus (Kumar, Rahul et.al 2021). The rich fisheries and agriculture in the wetland system are the main source of livelihood of 15,000 households of 17 villages in and around the wetland who are engaged in harvesting fish, bivalves, and aquatic plants for use as food, fodder, and fuelwood (Ramsar Information Sheet 2020). The lake hosts 106 species of resident birds and is a nesting ground for 59 species of migratory birds. The lake is categorized as a highly eutrophic lake (Inland Water Bodies of Bihar, ICAR-CIFRI). The Wildlife (Protection) Act of 1972 designated Lake Kabartal as a notified area (Sinha 2021). In 1986, the Bihar state government proclaimed it a protected zone to prevent bird poaching (Ambastha et.al 2007), and in 1989, the Indian government designated it as a bird sanctuary (Singh et.al. 2021). The Ministry of Environment and Forests, Government of India, designated it as a Lake of National Importance and included it in the list of National Wetland Conservation Programs in 2009(Singh et.al 2016, Singh et.al. 2021). It appears that the wetland's legal protection hasn't done much to assist, though. It is quickly getting smaller. In 2020, Kabartal Lake was declared a Ramsar Site (Ramsar.org).



Source: SRTM DEM

Need for the study

"The world has enough for everyone's needs, but not for everyone's greed," said M. K. Gandhi. The explosive increase in population has placed enormous strain on the environment's ability to meet the expanding needs. As a result, resource overexploitation has replaced optimal resource utilization. Growing population and advancement in Science and Technology, have led to the destruction of natural environments for fulfilling the need and greed of the people. More land is needed for agricultural activities, industrial growth, and infrastructure projects to provide the population's fundamental needs.

The growing population in and around Lake Kabartal is putting a strain on the resources of the wetland. More agricultural land is being reclaimed to fulfill the needs of the growing population around Lake Kabartal. The use of chemicals in farming has played a major factor in imbalancing the concentration of nutrients in the wetland as the water reaches there via surface runoff. The level of pollutants has increased in the lake (Singh, et. al. 2016). This is destroying the natural ecosystem of the wetland. The area of wetlands is continuously shrinking and a comparison of the years 1986 and 2010 shows that it has reduced by 66 percent since 2004 and

only 30 percent of the original coverage area is left, as recorded in 1984 (Prakash et. al. 2018). This shrinkage is due to a lack of awareness among people about its importance, climate change, and inefficient government policies. The current research will be an analytical and comprehensive study for maintaining wetland health, conservation, and framing policies so that its optimum utilization can be done. Good planning can be a win-win situation for both the stakeholders and the health of the wetland in general and even in particular.

Data Sources and Methodology

Primary and secondary data will be collected concerning the wetlands of Begusrai district which will constitute topographic sheets, satellite imageries of four decades, rainfall data, demographic information, photographs, samples, a socio-economic survey, etc.

Data sources

Secondary sources of data will include toposheets on various scales from the Survey of India for preparing a base map. Satellite data will be taken from USGS, IRS, and different agencies. For an extensive understanding of the wetlands, useful secondary data will be obtained from the Space Application Centre, ISRO's National Wetland Atlas, the Central Water Commission and the India Meteorological Department. Demographic information will be taken from the Census of India. Information will be gathered on the flora and fauna from the forest department as well as other relevant sources. Also, information from various published sources will be used.

A pilot study will be conducted to evaluate the association and disassociation of anthropogenic agents with the natural environment. A field survey will be conducted to verify the satellite data. A stratified random sampling technique will be used to collect primary data. Schedules, structured questionnaire surveys, and interviews will be done in the process of collecting the data. Water samples will be collected from specific locations of Lake Kabartal, and their physical and chemical properties will be analysed.

Mapping and documentation

LULC, NDWI, MNDWI, NDVI, VGI, and other indices will be mapped using GIS software. The MS Office package will be extensively used for report writing and tabulation of data.

Data analysis

In the physical aspect, land use and land cover analysis will be done utilizing satellite images of four decades using GIS software. Waterbody mapping will employ the Normalized Difference Water Index (NDWI) and the Modified Normalized Difference Water Index (MNDWI). To measure the influence of topography on hydrological processes, the Topographic Wetness Index (TWI) will be used. Assessment of physical and chemical parameters of water will be done to assess the quality of water and the result will be computed and mapped using statistical and GIS software. As regards to biological aspect, the Normalized Difference Vegetation Index (NDVI) and Vegetation Growth Index (VGI) will be used for vegetation cover and growth status. Analysis of flora and fauna will be done based on secondary data sources, supported by field observation and a questionnaire survey. The Modified Mann-Kendall Test, multivariate analysis, correlation, and other methods will be used in this study to process and analyse the data.

Tentative Chapter Scheme

Chapter 1

Conceptual framework of the study

Chapter 2

Wetlands of the study area

Chapter 3

Impact of Rainfall Variability on the Wetlands

Chapter 4

Lake Kabartal: An Environmental Approach

Chapter 5

Wetlands: Livelihood and Sustainability Goals

Chapter 6

Summary and Conclusion

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